Department of Buses

NYCT CLEAN FUEL BUS PROGRAMS

WMATA Alternative Fuels Workshop
July 6, 2000

Outline

- Overview of NYCT Bus Operations
- NYCT Goals
- NYCT “Clean Fuel” Bus Plan
- Compressed Natural Gas Buses
- Hybrid Electric Buses
- Clean Diesel Technologies

NYCT Bus Operations

- Number of Depots: 18
- Employees: 12,159
- Bus Routes / Bus Stops: 234 / 14,000
- Ridership: 2.0 million weekday
- Revenue Miles: 102 million annually
- Diesel Fuel Used: 40 million US Gal. in 1999

NYCT Bus Fleet

	2000	2006
40' Diesel Transit	3,862	2,022
45' Diesel Coach	280	660
60' Diesel Articulated	148	629
40' CNG Transit	90	649
40' Hybrid Transit	10	390
Total	**4,390**	**4,350**

NYCT Goals

1. Reduce Bus Fleet Emissions
   - *Achieve levels below current U.S. mandates*
2. Improve Service
   - *Improve equipment reliability*
   - *Achieve quieter operation*
3. Reduce the Cost of Operations
   - *Improve fuel economy*
   - *Reduce maintenance costs*
   - *Avoid infrastructure costs*

NYCT “Clean Fuel” Bus Commitment

- Program is technology neutral, and combines several different approaches
  - CNG Buses
  - Hybrid Buses
  - Clean Diesel Technologies
- Designed to give cost-effective emissions reductions as quickly as possible
- MTA 2000 - 2004 Capital Spending Plan includes $304 million for Clean Fuel Programs

2000 - 2004 Capital Plan

- Expand CNG Bus Operations
  - Purchase 300 buses and convert 2 depots to CNG
- Expand Hybrid Bus Programs
  - Purchase 250 hybrid buses
  - Develop hybrid articulated and coach buses
- Expand the Use of Clean Diesel technologies
  - Retire all 2-stroke diesel engines by 2003
  - Convert entire fleet to reduced sulfur fuel
  - Retrofit 3,500 buses with catalyzed exhaust filters

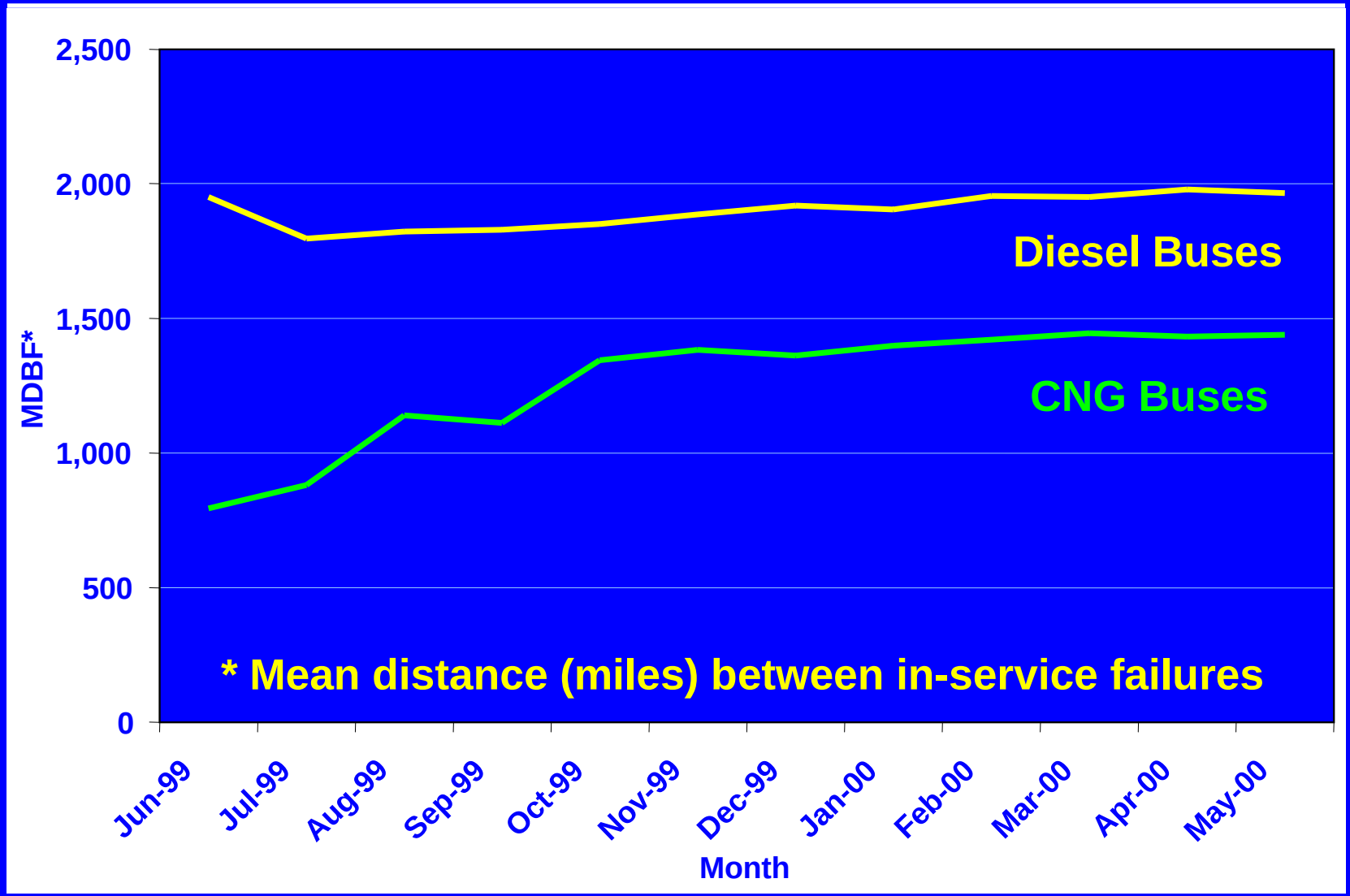
NYCT CNG Bus Program

- Have operated 34 CNG buses since 1995
- In 1999, the program expanded to 90 buses at one depot
- Have installed one fast-fill CNG fuel station capable of fueling 30 buses/hour
- Over 3.2 million miles operated in revenue service to date
- A second CNG depot is under construction, and 259 CNG buses are on order

CNG Lessons Learned

- CNG Buses work - they can be used to successfully provide passenger service
- CNG Buses are only 50 - 75 % as reliable as comparable diesel buses
- CNG buses are 41% less energy efficient than diesel buses in urban service
- CNG buses are significantly more expensive to operate than diesel buses

CNG Bus Reliability



CNG Bus Costs

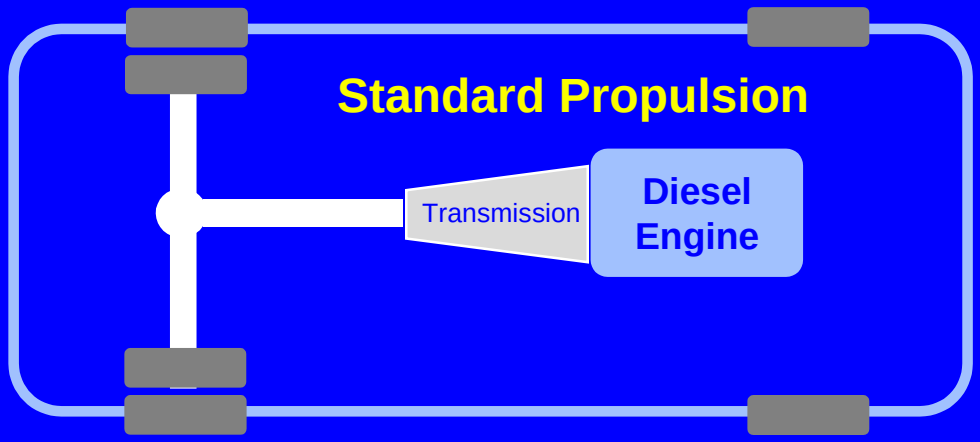
- MAINTENANCE
  - $0.20/mile more than diesel buses
- FUEL
  - $0.16/mile more than diesel
- Infrastructure
  - $5 million/depot for fuel station (30 bus/hr capacity)
  - $10 - $40 million/depot for safety modifications
  - Significantly greater costs for constrained urban sites, especially for multi-story depot buildings

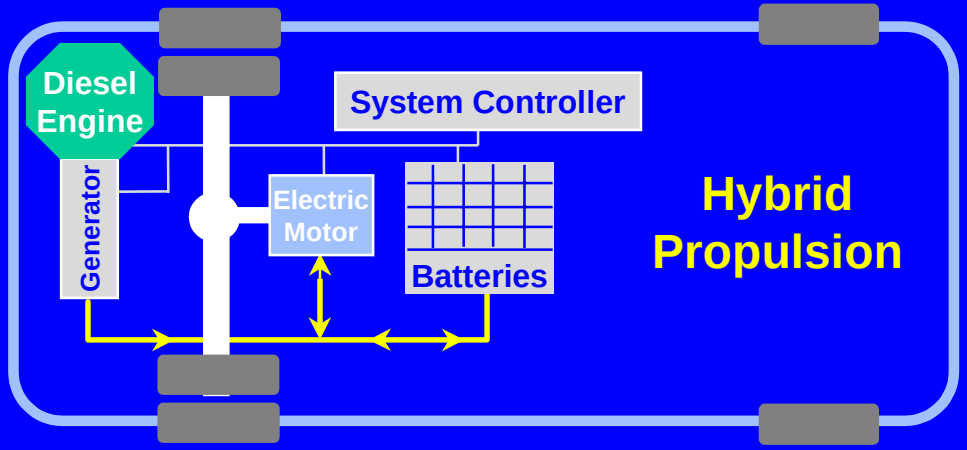
Hybrid Electric Buses

- Hybrid Electric buses combine a diesel engine and electric drive components
- Improved performance
  - Significant emissions reduction
  - Increased fuel economy
  - Smooth and quiet operation
- Avoids the infrastructure costs of CNG - no special fuel handling is required

Hybrid vs. Conventional System

Large IC Engine
and Mechanical
Transmission





Small IC Engine
Generator
Electric Drive Motor
Energy Storage
System Controller

NYCT Hybrid Bus Programs

- Successful prototype in 1996 (Orion/GE)
- Hybrid retrofit for RTS bus - revenue service testing completed March 2000 (Allison/Nova)
- Two pilot fleets of hybrid buses ordered
  - 5 Orion/Lockheed buses entered revenue service 9/98; 5 more entered service 5/00
  - 5 Nova/Lockheed buses due by late 2000
- 125 additional Orion/Lockheed buses ordered for delivery starting late 2001

ORION/Lockheed Hybrid Bus

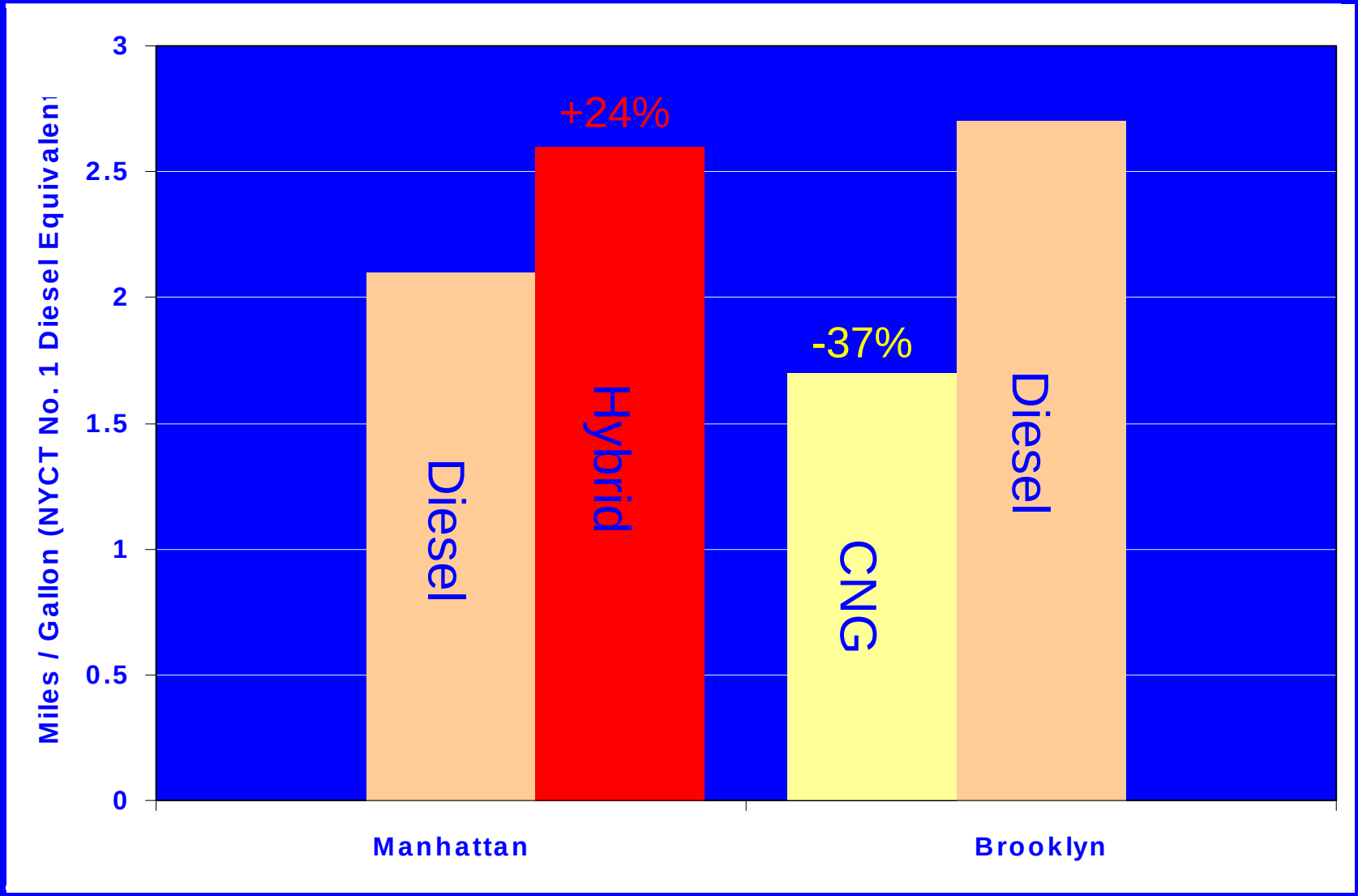
Hybrid Revenue Service Experience

- Hybrid buses in service since Sept. 1998
- 135,000 revenue miles accumulated to date
- Very positive - for a brand new technology, have exceeded expectations
- Experience to date compares favorably to other new technology introductions
- NYCT is very encouraged for the future and will continue to expand our program

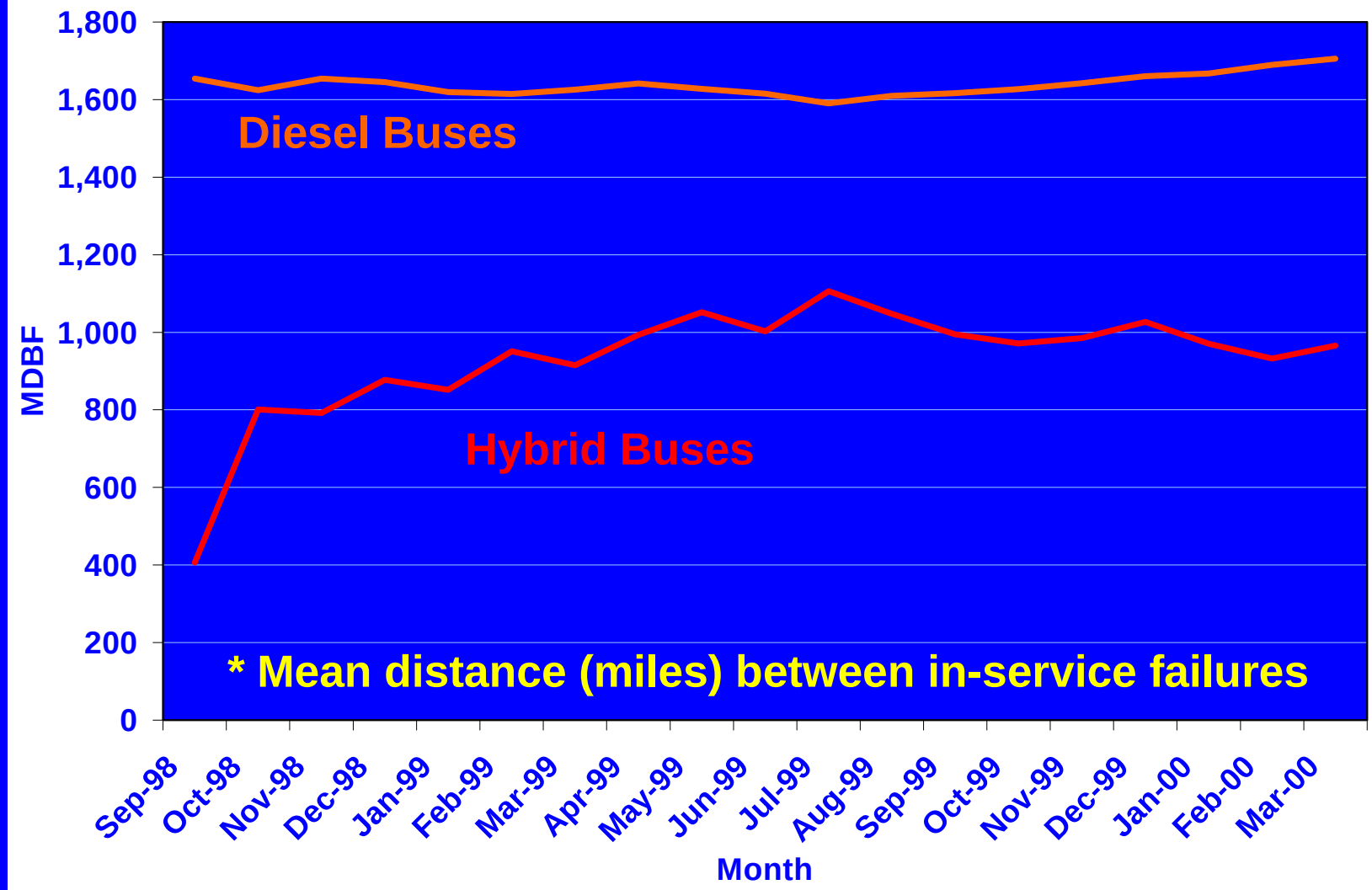
NAVC Emissions Testing

- Diesel hybrid electric buses offer emissions comparable to CNG buses
- 50-90% lower PM than standard diesel buses
- 30-60% lower NOx and HC
- 20-40% lower greenhouse gases than CNG or standard diesel
- Significantly better fuel economy than CNG or standard diesel
- Emissions testing data is available online at www.navc.org/emissionsreport.html

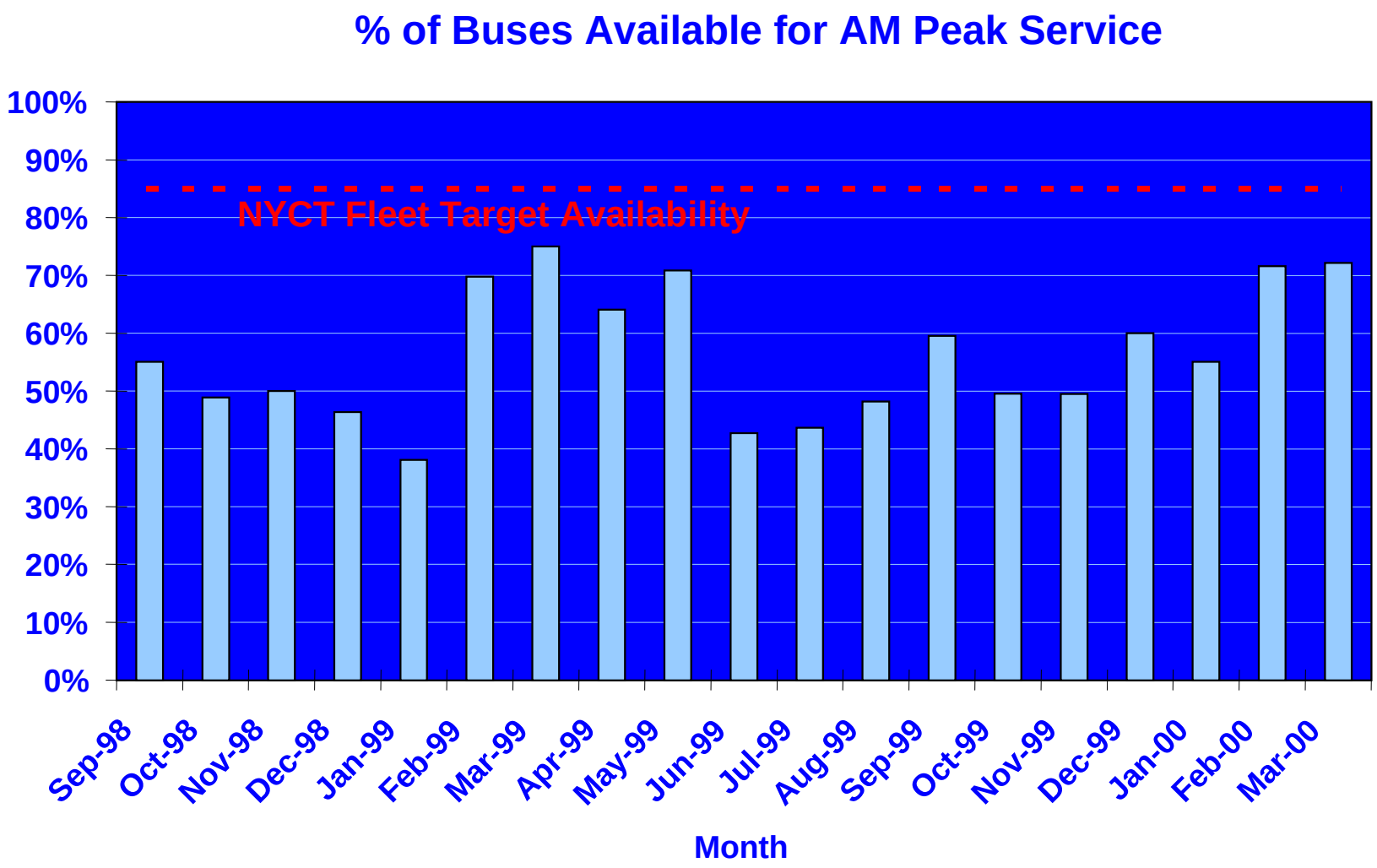
Hybrid Bus Fuel Economy (MPG)



Hybrid Bus Reliability (MDBF*)



Hybrid Bus Availability



Hybrid Lessons Learned - Operational

- Bus operators and passengers like hybrids
  - Quiet, smooth operation
  - excellent acceleration/smooth braking
  - “feels” like a standard bus
  - little or no operator training required
- Able to be used on all NYCT routes
- Bus does not roll back on hills
- Performance can be customized

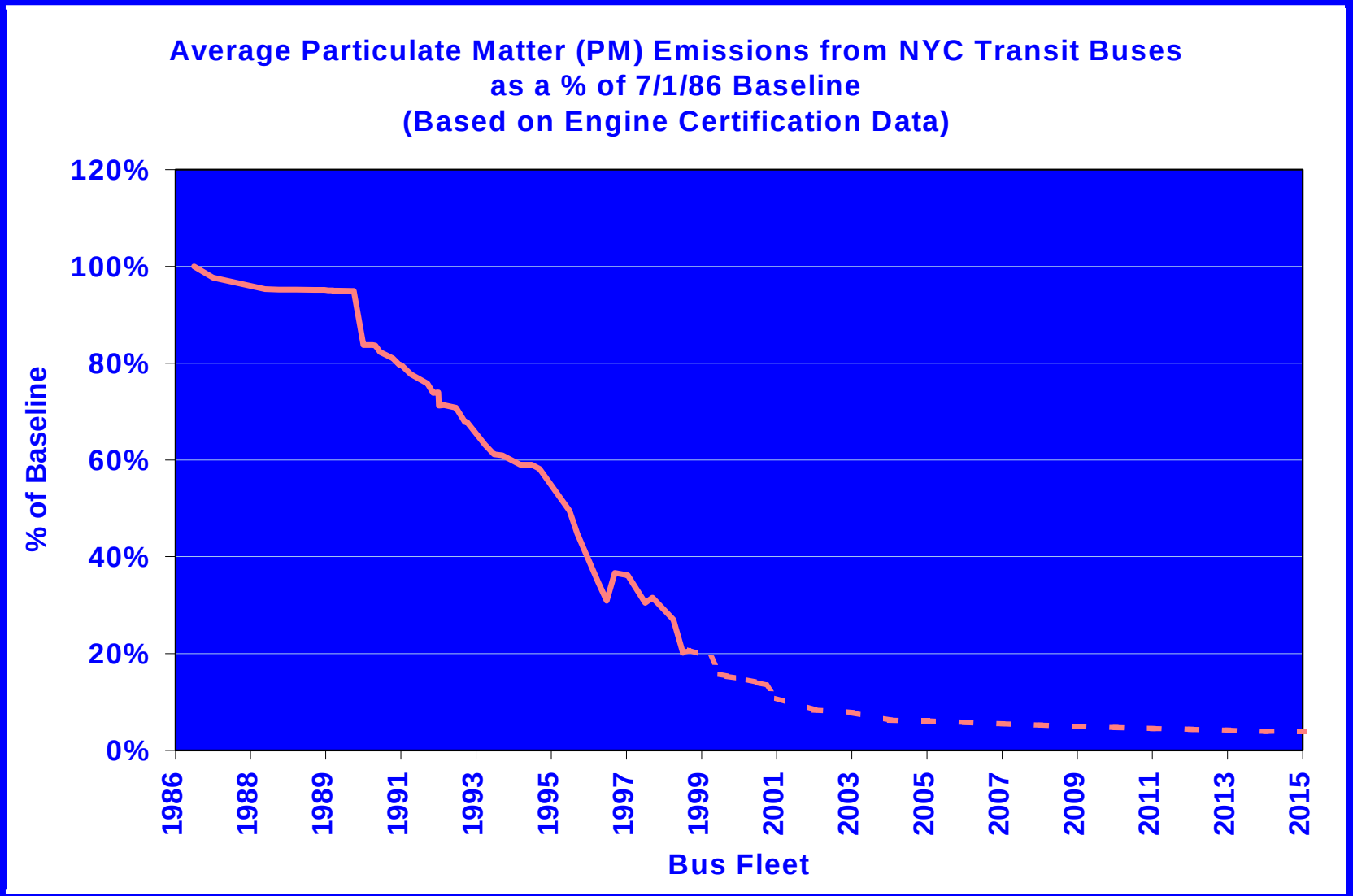
Hybrid Lessons Learned - Technical

- Battery equalization and periodic battery “conditioning” are both required
- Programming must deliver a stable Control System
- Some early component failures - required redesign
- Catalytic Exhaust Filter durability to be determined - key to emissions performance
- “Cleaner” small diesel engines are needed, with hybrid-specific engine programming

Clean Diesel Fleet Replacement

- Modern diesel engines are 94% cleaner than engines purchased 10 year ago
- Retirement of older diesel buses, and replacement with new buses is an effective and cost-effective emissions reduction strategy
- As part of its clean fuel commitment, NYCT will retire all pre-1990 2-stroke diesel engines by 2003, either by retiring the bus, or by re-powering with a modern engine

NYCT Fleet PM Emissions



Advanced Exhaust After-Treatment

- Catalyzed Exhaust Filters
  - Oxidation catalyst and wall-flow ceramic filter
  - Packaged to replicate OEM muffler dimensions
  - No moving parts
  - No external energy requirements
- Reduced Sulfur Diesel Fuel
  - Base specification similar to #1 Diesel
  - Sulfur level of 30 ppm (350 - 500 ppm standard)
  - Lubricity enhancement

CRT ™ Fleet Demonstration

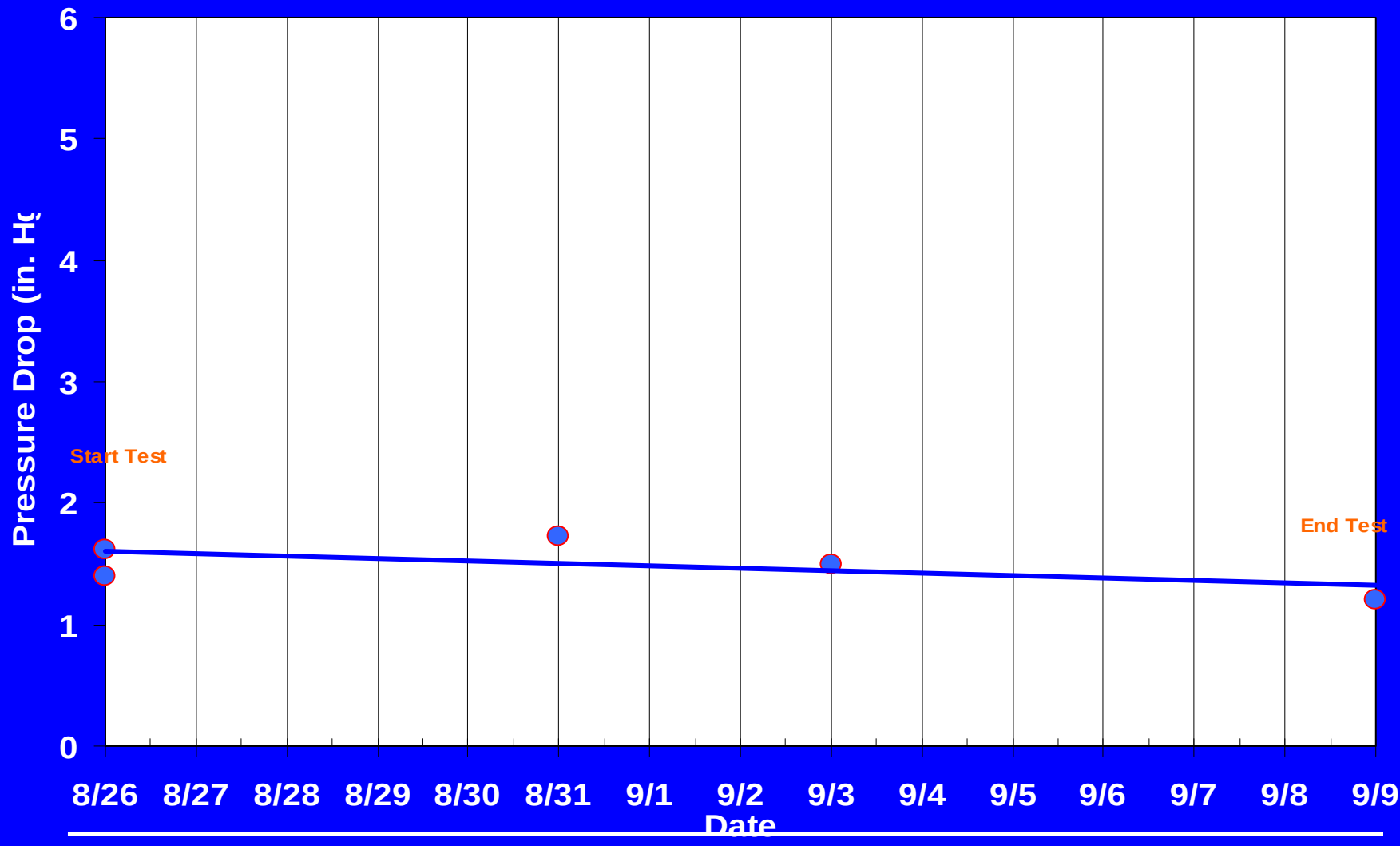
- 50 buses equipped with CRT catalyzed filters in revenue service in Manhattan for one year
  - 25 1999 buses with Detroit Diesel Series 50 engines
  - 25 1993 buses with Detroit Diesel 6V92 DDEC engines
- One entire depot (140 buses) to operate on reduced sulfur fuel for one year (1.2 mill gallons)
- 4 buses equipped with continuous data loggers; all others will be monitored monthly for changes in engine back-pressure, and fuel economy

CRT Demonstration Results - S50

- Prototype testing showed in-service exhaust temperatures to be very acceptable
- Fleet demonstration kicked off Feb. 1, 2000
- Currently have 25 CRT buses in service
- CRT buses have logged over 260,000 miles
- No CRT-related road calls to date; MBDF of CRT fleet is equivalent to non-CRT buses
- No back-pressure problems to date
- No measured loss of fuel economy

CRT Installation S50 Engine

S50 Back Pressure*



Emissions Test Results: S50 on CBD

REDUCTION FROM BASELINE	CO	HC	NOx	PM
Reduced Sulfur Fuel	23 – 33%	66 – 84%	+ 8 – 9%	13 – 33%
CRT & Reduced Sulfur Fuel	89 – 95%	83 – 99%	+ 0 – 9%	81 – 93%

- Baseline numbers consistent with other recent testing
- PM, HC, & CO emissions comparable to CNG
- Toxic analysis & particle size analysis not yet complete